NORTHERN ARIZONA UNIVERSITY
The W. A. Franke College of Business

Impact Analysis of Arizona Forest Restoration Products' Oriented Strand Board Facility

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Project Summary

After a century of logging, grazing, and fire suppression, the ponderosa forests of northern Arizona are well outside the historic range of variability and are highly susceptible to unnatural crown-fires and insect epidemics. A comprehensive, state-wide effort to reduce overall tree densities has begun, in hopes of returning ecological integrity to the forests and reducing the high fire risk to forested communities and private properties. These efforts have resulted in many small fuels reduction/forest restoration programs throughout northern Arizona. However, the scope of the problem covers millions of acres, and fuels reduction programs are focused on removing primarily small diameter material. With a lack of markets for the small diameter wood, returning northern Arizona's forests to a more natural fire regime has a tremendous price tag, only a fraction of which is currently provided for by federal subsidies. A general lack of funding is the primary obstacle to achieving the large-scale forest restoration envisioned by scientists, politicians, and the public.

In response to the financial dilemma surrounding fuels reduction programs in Arizona, Arizona Forest Restoration Products Inc. (AZFRP) of Flagstaff, AZ has proposed to invest $375 million dollars in processing facilities and operations to turn small diameter ponderosa pine needing to be removed into oriented strand board (OSB). OSB, a building material similar to plywood, is an excellent match with the structural properties of small diameter ponderosa pine. OSB would also provide the most return to investment of any existing markets for small diameter ponderosa, making it the wood product of choice for funding large-scale forest restoration.

While an OSB facility would have widespread ecological and social benefits in the form of providing the fiscal impetus for treating northern Arizona's forests, it could also have tremendous economic impacts on regional economies in the form of output, employment, income, and tax generation. The purpose of this study is to determine the economic impacts that would result from AZFRP's planned oriented strand board facility in Winslow, AZ. Input-output (I-O) modeling, along with the economic modeling software IMPLAN, were the primary methods used to analyze the economic impacts. **Accordingly, the study was based upon estimates and data reported by AZFRP. No**

forecasts were begun with an assumed or estimated parameter. The information provided by AZFRP was taken as datum and no attempt was made to verify or audit the underlying assumptions, financial systems and procedures. I-O modeling measures the impacts on regional economic characteristics and other industries that result from the creation of a new business.

Background

The economic impact analysis was spurred by regional community leaders wanting a deeper understanding of how their community economies might be affected by AZFRP Inc.'s OSB operations. Knowing the estimated impacts can provide greater support and information concerning future development of wood product industries.

The study was conducted by researchers with the Bureau of Business & Economic Research, a service unit for The Center for Business Outreach located in The W. A. Franke College of Business at Northern Arizona University. The principal investigator for the economic impact analysis was Dr. Evan Hjerpe of the School of Forestry at Northern Arizona University. The co-principal investigator was Dr. Ronald Gunderson of The W. A. Franke College of Business at Northern Arizona University.

Process

Economic impact analysis was conducted to measure the economic effects of augmenting and enhancing new and existing wood harvesting and processing industries in northern Arizona. To project the economic impact, assumed levels of employment were entered into the regional economy of Apache, Coconino, and Navajo Counties. The changes in final demand were entered into IMPLAN's Impact Analysis, providing a detailed chain of correlating impacts in varied aspects of regional economies. Economic impact analysis requires a number of methods and models, and these are presented in detail in the full report.

Projected employment and output data were provided by AZFRP Inc. Regional economic information for Apache, Coconino, and Navajo Counties was supplied by Minnesota IMPLAN Group Inc.

Findings

The economic impacts of OSB production were broken into two categories: the recurring annual impacts associated with harvesting and facility operations and the one-time impacts associated with the construction of the facility. The recurring annual impacts were further categorized into annual tree harvesting operations (Group A Activities), annual facility operations (Group B Activities), and annual biomass power generation (Group C Activities). Table ES-1 shows the effects and multipliers for output, employment, and labor income that will result from the recurring annual impacts (Groups A, B, and C).

Table ES-1. Annual Effects[1] and Multipliers of Regional Impacts by AZFRP Inc.'s OSB Production.

Economic Impacts	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Type SAM Multipliers
Total Output ($)	119,117,600	35,642,200	15,171,400	169,931,100	1.43
Total Employment (FTE jobs)	256	177	157	589	2.31
Total Labor Income ($)[2]	19,186,700	7,511,500	4,853,100	31,551,400	1.64

[1]Effects are presented in 2008 dollars.
[2]Total labor income includes employee compensation and proprietor income.

The one-time impacts associated with the construction of the facility (Group D Activities) also represent a surge in regional economic activity. The construction of the facility will include local laborers, suppliers, fabricators, infrastructure needs, specialized labor, and raw materials. Table ES-2 summarizes the overall impacts and multipliers for output, employment, and labor income associated with initial facility construction.

Table ES-2. Annual Effects1 and Multipliers of Regional Impacts by AZFRP Inc.'s Construction of OSB Facility

Economic Impacts	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Type SAM Multipliers
Total Output ($)	55,601,500	9,326,300	9,404,600	74,332,400	1.34
Total Employment (FTE jobs)	274	84	97	455	1.66
Total Labor Income ($)[2]	12,327,600	3,119,800	3,008,000	18,455,500	1.50

[1]Effects are presented in 2008 dollars.
[2]Total labor income includes employee compensation and proprietor income.

Other main economic impacts include:

- Overall, 230 industrial sectors will be annually impacted by AZFRP Inc.'s OSB operations.

- Initially, some $244 million of economic output will be generated by AZFRP Inc. and over 1,000 jobs will be created. Once operations are up and running, total output of $170 million will be annually injected into the regional economy, along with almost 600 employment opportunities.
- Recurring annual OSB operations (Groups A, B, and C) will generate some $1.1 million of business taxes stemming from direct effects.
- Including indirect and induced effects, approximately $2.77 million of business taxes will be generated for regional economies from annual OSB operation (Groups A, B, and C).
- Facility construction (Group D) will generate an estimated $688,000 in business taxes from direct effects and $1.63 million in total taxes for regional economies when including indirect and induced effects.
- Total tax impacts, including local, state, and federal, will be $10.4 million for annual OSB production (Groups A, B, and C) and $5.6 million for facility construction (Group D).
- Calculated multipliers for this study, ranging from 1.34-2.31, are significantly higher than previously calculated multipliers for tourism and recreation sectors in the region, illustrating the importance of diversifying northern Arizona economies.

Economic Impact Analysis of Arizona Forest Restoration Products' Oriented Strand Board Facility

Introduction

Wood products industries have been important to northern Arizona since European settlement in the late 1800s. There has been tremendous fluctuation in amount and types of woody material removed from northern Arizona public forests, resulting in ever-changing wood products industries. Regional forest health conditions have also varied in the last century. Due to a number of factors including overgrazing, high-grade logging, and fire suppression, current forest conditions in northern Arizona consist of an overabundance of small diameter ponderosa pine, and are consequently subject to uncharacteristically intense and destructive wildfires (Covington and Moore 1994). In an attempt to restore forest health and reduce overall wildfire risk, forest managers in the Southwest are conducting fuels reduction programs focused on mechanical thinning and prescribed burning. Regional fuels reduction programs are producing a large excess of usable ponderosa pine wood fiber, primarily in the 5 in. diameter-at-breast-height to 16 in. diameter at-breast-height range. Currently, there are limited market outlets for the utilization of this small diameter material, leaving fuels reduction programs to occur at a slow pace and in a costly manner. Certainly, the utilization of fuels reductions byproducts would provide substantial increases for treating a greater number of acres. Having greater funding available, through market returns, would spur increased ecological enhancements to the forest and could also create significant economic impacts to regional communities.

With an emergent focus on reducing tree densities, conditions are ripe for the byproduct utilization of the small-diameter material being produced in regional fuels reduction programs. Arizona Forest Restoration Products Inc. (AZFRP) is a local business planning to construct a large-volume, state of the art, oriented strand board (OSB) manufacturing facility in Winslow, Arizona. AZFRP Inc. plans on working with a number of regional national forests to conduct fuels reduction programs aimed at reducing the overall threat of unnatural, large, crown fires to communities and private residences throughout northern Arizona.

The purpose of this report is to present the economic impacts associated with OSB production (based upon AZFRP's estimates). Numerous economic impacts could be generated from a large-volume manufacturing facility in northern Arizona. The proposed OSB plant may spur regional increases through the creation of direct employment, subsidiary industrial employment (harvesting, etc.), regional output, labor income, and regional tax bases. Estimation of the economic impacts of an upcoming project can be used in comparison to other projects, can be incorporated into an accounting system for projects such as cost-benefit analysis, and can illustrate overall contributions to regional economies and tax bases if certain assumptions are realized.

Methods

Economic impact analysis was used to measure the potential economic effects of augmenting and enhancing new and existing wood harvesting and processing industries in northern Arizona. To project the economic impact, assumed levels of employment were entered into the regional economy of Apache, Coconino, and Navajo Counties. The changes in final demand were entered into IMPLAN's Impact Analysis, providing a detailed chain of correlating changes in varied aspects of regional economies. Economic impact analysis requires a number of methods and models; the following paragraphs detail the methods used by the investigators to conduct the economic impact analysis for AZFRP's proposed OSB facility. The methods section contains: the study methodology for impact analysis including Input-Output (I-O) modeling and IMPLAN, the geographic scope of the regional analysis, data acquisition, and a detailed listing of final demand changes entered into the impact analysis.

Study Methodology

The Input-Output (I-O) model is an important tool used in assessing the potential economic impacts of specific activities, and was the primary economic modeling framework used for the economic impact analysis. The I-O model is classified as a conditional predictive model, designed to predict changes in an economy resulting from a particular stimulus and is considered one of the best methods for analyzing the interactions of various industries of an economy and linking these industries to their sources of economic stimuli (Davis, 1990). The I-O model incorporates transaction tables to keep track of inter-industry sales and purchases, as well as exogenous sectors of final demand such as households (can be considered exogenous or endogenous), government, and foreign trade. The name, "I-O Model," is a result of each industrial sector in the model being both a buyer and a seller of inputs and outputs.

The I-O model can be used to conduct economic impact analysis. IMPLAN Professional 2.0 is a Forest Service-created, operationalized I-O model that uses aggregated databases to construct a picture of the regional economy. Economic impact analysis involves applying a final demand change to the economic I-O model, and then analyzing the resulting changes in the economy (IMPLAN Analysis Guide, 1999). Impacts can be one-time impacts, such as the construction of a new building, or they can be recurring impacts, such as the arrival of a new industry. Often, the impact analysis is concerned with multiplier effects, or the amount of money that is re-circulated through the economy after an initial expenditure.

The social accounting matrix (SAM) is the basis for our input-output predictive model. This predictive model will be used to estimate changes in the regional economy due to proposed/planned expenditures related to the construction and operation of an OSB facility. The assessment of changes will be shown in predicted multipliers, which are the total economic impacts generated in the regional economy divided by direct impacts. These multipliers capture the backward linkages associated with final transactions. Backward linkages are the goods and services purchased by an industry in order to produce a final product. With wood products industries, backward linkages are represented by the proposed transactions of AZFRP Inc. with local suppliers of raw material, utilities, services, and other necessities.

Multipliers are a measure of the extended economic activity generated by an initial injection of capital. There are three main multipliers typically used in regional impact analysis to measure: 1) the effect on regional output, 2) the effect on household income, and 3) the effect on regional employment. Comparisons of output multipliers show government agencies and private businesses where additional spending would result in the greatest impacts in terms of total dollar value output (Miller and Blair, 1985). Two of the most significant economic indicators in rural areas are per capita income and employment levels. Knowing employment and income multipliers gives regional managers an informed perspective of the short-run impacts of a particular project or policy change.

Output, income, and employment multipliers can be calculated in various ways. Type I multipliers are the most conservative estimates and are produced by dividing the sum of direct and indirect effects by the direct effects. Type II multipliers internalize household consumption, treating households as another industry in the social accounting matrix. Type II multipliers are calculated by dividing the sum of direct, indirect, and induced effects by the direct effects. Type II multipliers generally produce the largest estimates. Type III multipliers refine the induced effects added to the Type II multiplier by incorporating Personal Consumption Expenditures (PCE) to provide a more realistic pattern of household consumption within the defined region. The formula for producing Type III multipliers is the sum of direct, indirect, and induced effects divided by direct effects. Type SAM multipliers (generated by IMPLAN) are consistent with Type III and Type II multipliers but allow researchers to also internalize institutions (federal and state governments, investments, tax collection, etc.) along with households. Thus, the researcher can include all factors and institutions germane to their specific region. For this study, Type SAM multipliers were calculated.

The resulting multipliers delineate three separate components of regional economic activity. These components are direct effects, indirect effects, and induced effects.

1. Direct effects are the changes in the industries to which a final demand change was made.

2. Indirect effects are the changes in inter-industry purchases as they respond to the new demands of the directly affected industries.
3. Induced effects typically reflect changes in spending from households as income increases or decreases due to the changes in production. (IMPLAN Analysis Guide, 1999). These effects show the circular flow of goods and services in a region.

The economic impact analysis performed measured the potential effect of the OSB facility and AZFRP's harvesting divisions on the following economic indicators:

1. The direct, indirect, and induced effects on regional output, employment, labor income, and taxes;
2. The multiplier effects on regional output, employment, and labor income;
3. The overall number of affected industrial sectors, including a list of the most affected industrial sectors; and
4. Site-specific extrapolation of impacts and findings.

Input-Output modeling and economic impact analysis is a broad subject, with years of scientific refinement and numerous methodological components. Only a brief synopsis of entire methods was presented above; for a more detailed explanation of methods, please refer to Appendix B. Each impact analysis project is specific to the defined regional economy, necessitating a number of updates and edits for the industrial sector relationships provided by IMPLAN Inc.'s county data. Methods for IMPLAN regional data edits are provided in Appendix A.

Study Area

The defined study area for economic impact analysis includes the county housing the processing facility and surrounding counties impacted by AZFRP's intended harvesting and transportation operations. Increasing the defined study area to include all of Arizona or portions of New Mexico would dilute overall impacts and would not be representative of the socioeconomics for the most affected regions. Proposed plant construction and operations will occur in Winslow, AZ located in Navajo County. Field operations will be on portions of the Coconino, Kaibab, and Apache-Sitgreaves National Forests located primarily in Coconino, Navajo, and Apache Counties.

Data Acquisition

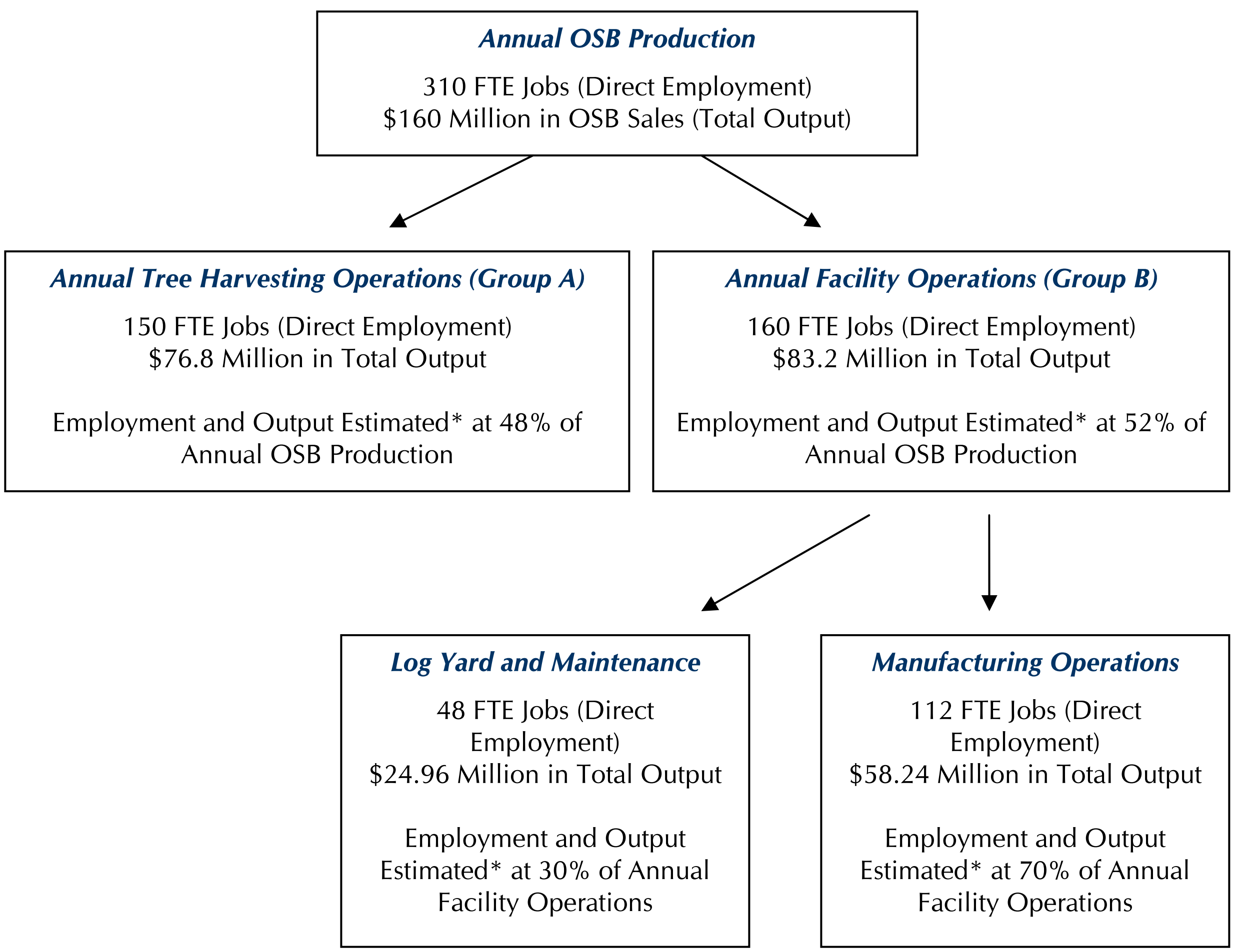
Two main types of data were needed to conduct the economic impact analysis: 1) the estimated direct impacts of the OSB facility in terms of direct employment or overall output and 2) the most up-to-date structural accounting matrices (SAM) detailing the presence and dependence of all existing industries for the defined study area. The principal investigators worked with the AZFRP Inc. CEO and managers to determine the most reasonable estimates of direct employment or output that will be generated from the construction and ongoing operation of a large-volume OSB facility. Secondary data consisting of the most recent (2004) county structural accounting matrices was purchased from the Minnesota IMPLAN Group Inc.

Final Demand Changes Created by OSB Production

Impact analysis involves estimating the new contributions to a regional economy due to changes in final demand stemming from the creation, loss, or augmentation of a specific industry. The change in final demand can be entered as either output or employment numbers; and these figures are the overall catalyst for impact analysis. Based on AZFRP Inc. economic data, the following figure (1) illustrates the main economic operations that could contribute to overall, annual OSB production. Figure 1 shows the general categorization of employment, as well as the amount each operation potentially contributes to total output.

Figure 1: Breakdown of Operations Contributing to Annual OSB Production

* All estimates provided by AZFRP



Overall operations categories (seen in Figure 1) can be further categorized, providing greater detail concerning the specific industrial sectors that could be affected by regional OSB production. Figure 1 shows that annual OSB production consists primarily of tree harvesting (Group A activities) and facility-based operations (Group B activities). An additional group of activities (C), related to biomass power generation, are intended to utilize wood residue generated from OSB production. These three group activities (A, B, and C) consist of numerous individual activities that represent the changes in final demand that are entered into IMPLAN's Impact Analysis. While group activities A, B, and C will be reoccurring annually, initial facility construction (Group D) contains a group of activities that will occur only once, representing a one-time surge in economic impacts. Due to this difference, Group D economic impacts are presented separately from annual impacts. Estimated sector impacts used for the impact analysis are detailed below.

Group A Activities—Annual Tree Harvesting Operations

Group A activities, or the logging component of AZFRP Inc.'s operations, can be further broken down for the impact analysis, so as to properly allocate projected impacts to more specific industrial sectors. Based on previous research (Hjerpe and Kim, in revision), tree harvesting on public lands can be assumed to be comprised of 60% logging-specific operations (14), 20% truck transportation (394), 15% USFS administration costs (Federal Non-Military—506), and 5% for forestry support activities (18).

Allocating the 150 direct jobs attributed to Group A activities to specific sectors provides the following estimated annual impacts in the form of full-time equivalent (FTE) employment opportunities:

-Logging (14)	= 90 FTE jobs
-Truck Transportation (394)	= 30 FTE jobs
-USFS Administration (506)	= 23 FTE jobs
-Agriculture and Forestry Support Activities (18)	= 7 FTE jobs
Total Group A Employment Impacts	**150 FTE jobs**

Group B Activities—Annual Facility Operations

The annual operations of the proposed OSB facility comprise Group B activities. Logs will be delivered to the plant in Winslow, AZ, milled and processed into oriented strand-board. Based on economic information provided by AZFRP Inc., site-specific operations at the OSB facility represent approximately 52% of annual employment and output, or 160 direct jobs (see Figure 1). Similar to Group A activities, annual operations at the OSB facility can be categorized into different sectors to provide greater detail in the impact analysis. Further economic data provided by AZFRP Inc. estimates that employment at the facility will consist of 30% actual OSB-production (Veneer and Plywood Manufacturing—115), 18% sawmilling (112), 18% energy requirements (Power Generation and Supply—30 and Natural Gas Distribution—31), 12% shipping and transportation of product (Rail Transportation—392 and Truck Transportation—394), 12% management of operations (451), and 10% equipment, parts, and maintenance (Commercial Machinery Repair and Maintenance—485). Using these ratios to allocate the 160 jobs directly attributable to Group B activities produces the following annual impacts:

-OSB Production (Ven. and Ply. Manu.—115)	= 48 FTE jobs
-Sawmilling (112)	= 29 FTE jobs
-Energy Requirements	
(50%) Power Generation and Supply (30)	= 14 FTE jobs
(25%) Natural Gas Distribution (31)	= 8 FTE jobs
(25%) State and Local Govt. Electric Util. (498)	= 7 FTE jobs
-OSB Shipping and Transportation	
(75%) Rail Transportation (392)	= 14 FTE jobs
(25%) Truck Transportation (394)	= 5 FTE jobs
-Management of Company and Operations (451)	= 19 FTE jobs
-Commercial Machinery Repair and Maintenance (485)	= 16 FTE jobs
Total Group B Employment Impacts	**160 FTE jobs**

Group C Activities—Annual Biomass Power Generation

In addition to the potential overall employment and output created by AZFRP's OSB facility, wood residue generated from sawmilling operations can be utilized by a co-located biomass power generating facility in Winslow, AZ. The biomass facility is considered additional output, exogenous to the actual OSB production, and has been estimated by AZFRP Inc. to provide an additional 30 jobs to the regional economy. The creation of a biomass electricity production facility will spur the following annual economic impacts:

-Power Generation (State and Local Govt. Electric Utilities –498)	= 30 FTE jobs

Group D Activities—Facility Construction

Another very significant potential economic impact is related to the construction of the OSB facility. However, unlike the re-occurring annual operations of OSB production, the construction of the facility is a one-time impact, providing a surge in regional economies.

Construction of the facilities required for OSB production involves numerous regional and imported services, goods, and raw materials. AZFRP Inc. has provided seven categories of expenditures needed to make the facility and grounds operational. The categories of expenditures made primarily within the regional economy include: (1) local non-trade labor (e.g. carpenters, dry-wall and brick layers, and waste/garbage disposal), (2) local suppliers (e.g. lumber, plumbing, piping and electrical work, consumables, etc.), (3) local fabricators for construction of storage tanks, conveyors, log decks, transfer tables, storage bins, etc., (4) site work (excavation, water, sewer and drainage, surfacing concrete and asphalt, etc.), and (5) construction of production buildings. Two expenditure categories that will rely more heavily on out-of-region materials and services are: (6) specialized labor (e.g. mechanical processes, engineers, installation, etc.), and (7) raw materials (2400 tons of steel). Based on economic data from AZFRP Inc., construction of the facility will have these one-time impacts:

-Local Non-Trade Labor	
(75%) Other New Construction (41)	= 110 FTE jobs
(25%) Waste Mgmt. and Remedial Serv. (460)	= 37 FTE jobs
-Local Suppliers	
(25%) Wholesale Trade (390)	= 16 FTE jobs
(25%) Building Materials (404)	= 16 FTE jobs
(25%) Machinery and Equip. Rental (434)	= 16 FTE jobs
(25%) Cutstock, Resawing lumber (118)	= 15 FTE jobs
-Local Fabricators (Fabricated Struct. Met. Manu.--233)	= 84 FTE jobs
-Site Work	
(25%) Water, Sewage, and Other Systems (32)	= 9 FTE jobs
(25%) Water, Sewer, and Pipeline Const. (40)	= 9 FTE jobs
(25%) Ready-Mix Concrete Manufacturing (192)	= 9 FTE jobs
(25%) Water Transportation (393)	= 8 FTE jobs
-Constructing Prod. Build. (Manu. and Industrial Build.-37)	= 63 FTE jobs
-Specialized Labor (Arch. And Engineering Serv.—439)	= 35 FTE jobs
-Raw Materials (Steel---All will be imported from outside of the region)	= 0 FTE jobs
Total Group D Employment Impacts	**427 FTE jobs**

Impact analysis is conducted in a regional economic structure from year 2004, the latest available data from IMPLAN Inc. Because annual operations (Groups A, B, and C) are not slated to begin until late 2009 or 2010, and facility construction will begin in 2008, all employment figures and correlating output have been deflated to 2004 dollars to match IMPLAN's latest economic structural matrices for the defined study area. Once the impact analysis was run, all values were then inflated back to 2008 dollars. Futhermore, IMPLAN models allow users to allocate the amount of local purchases through IMPLAN's calculated Regional Purchasing Coefficients (RPCs). Because many purchases of services and goods involve production and shipping costs from outside of the region, IMPLAN's RPCs estimate the amount of expenditures that will be retained within the defined region. The majority of final demand changes entered used the regional purchasing coefficients provided by IMPLAN Inc.

Results

The following sections detail the economic impacts projected to result from OSB production (based upon AZFRP estimates). The overall impacts can be separated into two categories: the continual, annually occurring impacts of OSB production and the one-time impacts occurring from facility construction. Impact categories include output, employment, value added, taxes, and overall impacts.

Annual Impacts of OSB Production

Economic impacts of the OSB operations were entered as employment totals for each industrial sector affected. A portion of the overall employment and output is immediately lost to products and services required for OSB production that are imported from outside the defined regional economy. Table 1 illustrates the annual effects and multipliers created by OSB production.

Table 1. Annual Effects1 and Multipliers of Regional Impacts by AZFRP Inc.'s OSB Production.

Economic Impacts	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Type SAM Multipliers
Total Output ($)	119,117,600	35,642,200	15,171,400	169,931,100	1.43
Total Employment (FTE jobs)	256	177	157	589	2.31
Total Labor Income ($)[2]	19,186,700	7,511,500	4,853,100	31,551,400	1.64

[1]Effects are presented in 2008 dollars.
[2]Total labor income includes employee compensation and proprietor income.

Output

In general, the term output refers to all the goods and services produced in a regional economy. Numerous industries are needed to contribute to the production of OSB. Table 2 shows the most affected industries and their contribution to direct and total output (includes indirect and induced output).

Table 2. Top Ten Affected Industrial Sectors in Millions of Dollars

Industrial Sector	Direct Output	Total Output
Logging (14)	44.09	62.12
Veneer and Plywood Manu. (115)	24.51	26.24
State and Local Govt. Elec. Util. (498)	14.83	15.77
Sawmills (112)	14.61	15.76
Power Generation and Supply (30)	3.87	4.16
Rail Transportation (392)	3.56	4.11
Truck Transportation (394)	2.37	3.64
Federal Non-Military (506)	2.60	2.60
Management of Enterprises and Co. (451)	2.02	2.38
Owner-occupied Dwellings (509)	0.00	2.17

Employment

Employment is one of the most often cited economic characteristics and is a good estimate of a project's overall economic impact. Employment figures hold even greater relevance in regions that consistently have higher unemployment rates than the national average, such as the Coconino, Navajo, and Apache Counties (U.S. Census Bureau: State and Country Quick Facts 2007). Table 3 shows employment by industrial sector that could be spurred by annual OSB production. Direct employment is directly associated with OSB operations, while total employment figures include the indirect and induced effects of OSB operations.

Table 3. Top Ten Affected Industrial Sectors in Full-Time Equivalent (FTE) Jobs

Industrial Sector	Direct Employment	Total Employment
Logging (14)	72.2	101.8
Veneer and Plywood Manu. (115)	43.8	46.9
Agriculture and Forestry Support Act. (18)	1.6	41.9
Truck Transportation (394)	20.8	32.0
State and Local Govt. Elec. Util. (498)	28.8	30.6
Food Services and Drinking Places (481)	0.0	27.8
Sawmills (112)	25.6	27.6
Federal Non-Military (506)	20.3	20.3
Management of Enterprises and Co. (451)	15.5	18.3
Rail Transportation (392)	10.6	12.3

With an anticipated 256 direct jobs being created in the regional economy, and another 334 being spurred through indirect and induced effects, the resulting employment multiplier effect is 2.31. For every OSB-related job, another 1.31 jobs are created, as OSB sectors need goods and services from other industries (indirect effects) and OSB employees re-circulate wages in the regional economy on food, housing, and health care (induced effects).

Labor Income

Labor income includes employee compensation and proprietor income and represents the disposable income that spurs the majority of induced effects. Generally, wages for employees involved in OSB production are higher than average regional wages. Table 4 provides the top ten affected sectors and the amount of direct and total labor income.

Table 4. Top Ten Affected Industrial Sectors in Millions of Dollars

Industrial Sector	Direct Labor Income	Total Labor Income
Logging (14)	5.36	7.56
State and Local Govt. Elec. Util. (498)	3.35	3.56
Veneer and Plywood Manu. (115)	2.72	2.91
Federal Non-Military (506)	2.38	2.38
Sawmills (112)	1.61	1.74
Rail Transportation (392)	1.23	1.42
Truck Transportation (394)	.75	1.16
Agriculture and Forestry Support Act. (18)	.34	.90
Management of Enterprises and Co. (451)	.73	.87
Power Generation and Supply (30)	.77	.83

Business Taxes

Annual OSB production could spur a significant amount of business taxes. Based on the estimated final demand changes, $1.09 million of direct businesses taxes will be generated for regional and local tax bases. Some $2.77 million of total business taxes will be annually generated when including indirect and induced effects. Total taxes reported are only paid out of labor income. A substantial portion of these taxes will be re-invested into the affected economies for infrastructure and community needs. Table 5 illustrates estimated tax generation for industrial sectors most affected *indirectly* by OSB production. While even more taxes are generated through direct effects, the illustration of taxes spurred through indirect effects (Table 5) provides a good description of associated sectors and their tax contributions.

Table 5. Estimated Tax Generation for Sectors Most Affected Indirectly by OSB Production (Thousands of $)

Industrial Sector	Indirect Business Taxes
Wholesale Trade (390)	181.6
Real Estate (431)	71.8
Coal Mining (20)	60.9
Automotive Repair and Maintenance (483)	39.2
Pipeline Transportation (396)	23.4
Telecommunications (422)	22.3

As seen in Table 5, service industries, raw material needs, and infrastructure needs are most affected indirectly (i.e. these industries are needed to support overall wood processing industries). In Table 5, only the top six indirectly affected sectors are presented. The business tax values shown in Table 5 represent a portion of total taxes generated through indirect effects, and are part of the $1.68 million of business taxes estimated via indirect and induced effects.

Overall Tax Impacts

The previous section details business taxes stemming from projected annual OSB production. While business taxes represent an important component of regionally impacted tax bases, they comprise only a small portion of overall tax impacts. Including federal and state tax impacts, annual OSB production will generate approximately $10.4 million in overall taxes. Because the majority of these taxes could be redistributed outside of the defined regional economy, a detailed assessment of total tax impacts is beyond the scope of this study. However, a listing of all tax impacts associated with projected annual OSB production is provided in Appendix C as additional information.

Facility Construction Impacts

Facility construction (Group D activities) involves a number of local builders, suppliers, and services, along with imported equipment and specialized labor that is not available in Coconino, Navajo, or Apache counties. Once again, a portion of the overall employment and output is immediately lost to products and services required for facility construction that are imported from outside the defined regional economy. Table 6 illustrates the annual effects and multipliers created by facility construction.

Table 6. Annual Effects1 and Multipliers of Regional Impacts by AZFRP Inc.'s Construction of OSB Facility

Economic Impacts	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Type SAM Multipliers
Total Output ($)	55,601,500	9,326,300	9,404,600	74,332,400	1.34
Total Employment (FTE jobs)	274	84	97	455	1.66
Total Labor Income ($)[2]	12,327,600	3,119,800	3,008,000	18,455,500	1.50

[1]Effects are presented in 2008 dollars.
[2]Total labor income includes employee compensation and proprietor income.

Output, Employment, and Labor Income

Multipliers calculated for output, employment, and labor income for facility construction are lower than the multipliers calculated for annual OSB production, but still represent positive economic impacts to the regional economy. The lower multipliers are reflective of the temporary nature of site construction impacts, as much of the construction workforce will not stay in the area permanently.

Business Taxes

In addition to the one-time surge in economic activity generated from the construction of the facility, there may be a substantial impact on regional and local tax bases. The impact analysis shows that expenditures related to the construction of the facility could spur $688 thousand of direct business taxes for regional and local governments. Including indirect and induced effects, approximately $1.63 million in regional business taxes will be spurred by plant construction (based upon estimates provided by AZFRP). A number of contractors and specialists will be brought into the region to help with construction of the facility, boosting local lodging, food and drink, and real estate services. These service sectors provide additional tax revenues, as local communities incorporate Bed, Board, and Booze taxes (e.g. 2% for Coconino County) and separate service industry taxation.

Overall Tax Impacts

Similar to the business taxes stemming from annual OSB production, the one-time business taxes generated from facility construction only represent a portion of total taxes collected. Including federal and state one-time tax impacts, facility construction could generate approximately $5.6 million in overall taxes. The majority of these taxes will be redistributed outside of the defined regional economy and are listed in detail in Appendix D.

Discussion

Initially, some $244 million of potential economic output will be generated by AZFRP Inc. and over 1,000 jobs are estimated to be created. Once operations are up and running, total output of $170 million will be injected into the regional economy annually, along with almost 600 employment opportunities. Overall, 230 industrial sectors could be annually impacted by AZFRP Inc.'s OSB operations.

The multipliers calculated for this study provide the most indicative results of economic importance when comparing OSB economic activity to other sectors of the economy. Multipliers ranging from 1.34 – 2.31 illustrate the positive economic impacts that could result from AZFRP Inc.'s proposed OSB operations, and show that investments in wood products clusters are generally more beneficial to the regional economy than the current leading industries of tourism and recreation. Previous research shows that tourism in northern Arizona generated output, employment, and income multipliers ranging from 1.31--1.39 (AHRRC 2005), while outdoor recreation generated multipliers ranging from 1.26-1.31 (Hjerpe and Kim 2007, Douglas and Harpman 1996).

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APPENDIX A

Methods for IMPLAN Regional Data Edits

In beginning the impact analysis, a few things become apparent when looking at the regional economic structure. First, the veneer and plywood sector (115) that will be significantly impacted does not currently exist in the regional economy, necessitating the creation of this sector in order to accurately assess total impacts. Secondly, the other two most affected economic sectors by OSB production (logging-14 and sawmilling-112) are present in the regional economy, but exist at a minimal level such that AZFRP Inc.'s annual operations would substantially change the economic characteristics of these sectors. Therefore, it is necessary to edit these sectors to make them more representative of future operations. The following paragraphs detail edits made to the regional economic structural matrices. All edits are conducted as suggested by IMPLAN authors and are based on data received from AZFRP Inc.

Employment and output percentages detailed in Figure 1, along with AZFRP Inc. estimates concerning employee compensation were used to update the regional economic information. Where data were absent, such as the categories of proprietary income, other property income, and indirect business taxes, Arizona state-wide sector information was used as a proxy for estimating these categories as a percentage of overall sector output.

IMPLAN software allows users to edit regional data based on expected economic information for proposed industrial activities. In the case of AZFRP's oriented strand-board facility, a number of changes were needed to be incorporated to the defined study area. The defined study area currently has no OSB or plywood production, necessitating the addition of this industrial sector (115—Veneer and Plywood Manufacturing) into the study area. The economic impacts of OSB production could be modeled in similar sectors that exist within the study area, such as Miscellaneous Wood Products (118), but incorporating the exact sector provides greater accuracy in the impact analysis. Existing industrial sectors that will be impacted by new economic activity in the region, such as Logging (14) and Sawmilling (112), also need to be edited to reflect anticipated output, wages and benefits, and employment that are substantially different from current industrial economic characteristics. The following paragraphs detail the edits made to the study area consisting of Apache, Coconino, and Navajo counties in Arizona.

Incorporating a Sector that Currently Does Not Exist in the Regional Data

Economic impact analyses are typically employment or output-driven models, where an industry's expected employment or annual sales are the primary drivers of regional economic impacts. Many economic components such as labor, capital, equipment, and services from other sectors are necessary to produce final goods and services that will be sold. Impact analysis details this chain of activities (direct effects), as well as providing information on the indirect and induced effects of overall output.

The potential economic impacts of AZFRP's oriented strand-board facility stem from a projected 310 direct jobs and $160 million of OSB sales. OSB sales are primarily an export industry, as most of the OSB will be sold to urban housing markets throughout the Southwest (Phoenix, Los Angeles, Albuquerque, and Las Vegas). The projected 310 direct jobs is the overall driver of the economic impact analysis. This annual employment can be divided into the main sectors that are the biggest contributors to OSB production: logging, sawmilling, and actual OSB manufacturing (see Figure 1). Each of the contributing sectors can be further broken down into smaller components. For example, logging contributions are comprised of actual logging, truck transportation, equipment maintenance and fueling, etc.

For the impact analysis, AZFRP assumed that 48 jobs, or 30% of facility-based employment, are allocated to actual OSB production. Because there is no OSB or plywood industry currently in the study area, this sector needs to be added to the regional data (See IMPLAN Tutorial: Adding a New

Industry). Information provided by AZFRP Inc. details the amount of employment and wages and benefits that will be required for OSB production. Table A-1 shows the projected economic breakdown of the AZFRP's OSB facility. Output, employment, and employee compensation data comes from AZFRP Inc., while proprietary income, other property income, and indirect business taxes values were approximated as a similar percentage of overall output as the Arizona-statewide veneer and plywood production sector (115).

Table A-1: Data for Added Industrial Sector: Veneer and Plywood Production (115)

Description	Value
Output (In Millions)	$24.96
Employment	48
Value Added (In Millions)	
Employee Compensation	$2.70
Proprietary Income	$0.07
Other Property Income	$0.62
Indirect Business Taxes	$0.08

Editing Existing Regional Industry Data

Other industries are affected by the creation of a new industry; logging and sawmilling for example, account for a large percentage of the $160 million in OSB final sales (output). The logging (14) and sawmilling (112) sectors are represented in the regional economic information for the three-county study area, but currently represent small components of the regional economy that will reflect greater capacity and employee compensation if AZFRP's OSB facility is operational. Therefore, existing industry sectors including logging (14) and sawmilling (112) were updated in the regional profile to better represent the flow of wood product clusters with other sectors under the addition of a large-volume manufacturing facility. (See IMPLAN Tutorial: How to make an industry look like your firm)

Tables A-2 and A-3 illustrate the economic values for these sectors in 2004, and the updated economic values for the regional economy as projected under AZFRP's annual operations. The "Projected Values" listed in Tables A-2 and A-3 represent the anticipated values in output and value added, once projected OSB production is underway. Using projected values for these sectors in the impact analysis provides greater accuracy in measuring the economic effects on other regional industries.

Table A-2. Updated Economic Values for Logging Sector (14)

Description	2004 Value	Projected Value
Output (In Millions)	$26.29	$62.98
Employment	123	123
Value Added (In Millions)		
Employee Compensation	$3.33	$7.38
Proprietary Income	$0.12	$0.28
Other Property Income	$2.65	$6.34
Indirect Business Taxes	$0.19	$0.46

Table A-3. Updated economic values for Sawmilling Sector (112)

Description	2004 Value	Projected Value
Output (In Millions)	$50.74	$118.80
Employment	230	230
Value Added (In Millions)		
Employee Compensation	$5.74	$12.85
Proprietary Income	$0.10	$0.24
Other Property Income	$5.68	$13.30
Indirect Business Taxes	$0.19	$0.44

APPENDIX B

An Introduction to I-O Modeling[1]

Historical Development

Input-output analysis is a branch of economic statistics, specifically, econometrics. The recent emergence of input-output analysis as a useful branch of economics dates from the development by Wassily Leontief in the 1930's of a general theory of production based on the economic interdependence of producing industries of the economy.

Early economists, notably Adam Smith, were concerned with the functioning of national economies or economies as a whole. Smith and other classical economists laid the groundwork for what is now referred to as macroeconomics. Much later, Alfred Marshall and his followers focused on the economics of the household and the firm. The method of these neoclassical economists, the founders of modern microeconomics, involved partial equilibrium analysis, that is, looking at "one thing at a time." John Maynard Keynes drew upon the work of both the classical and neoclassical economists in reviving interest in aggregative economics. While the neoclassical economists had concentrated on price theory -- examination of the forces that determine prices under given market conditions -- the Keynesians were concerned with the national economic forces that determined income and employment. Keynesians were concerned with the broad aggregates of total employment, total consumption, total investment, and national income. Neither Keynes nor the neoclassical economists was directly concerned with economic interdependence, or the way individual producing industries are knitted together in the structure that is the national economy.

Any developed economy, whether national, regional, or local, is characterized by a high degree of interdependence among producing industries of the economy. Each economic industry not only produces goods or services, but is also a consumer itself, purchasing other goods and services for use in the production process. Interindustry relations were recognized long before Leontief's time. Francois Quesnay's "Tableau Economique" of 1758 developed circular flow and general equilibrium concepts. The next major economist to focus on interindustry relationships was Leon Walras, who, in the 1870's, like his neoclassical contemporaries was interested in price determination. Unlike them, however, he was interested in the simultaneous determination of all prices in the economy, that is, general equilibrium analysis rather than partial equilibrium analysis. Walras examined both the interdependence of producing industries, and what each producing industry needed from other industries to produce a unit of a finished good. Walras believed his general equilibrium model to be a purely theoretical one; the model's computational problems were formidable. Further, the kind of national economic statistics needed for the model's database were rudimentary or nonexistent in his time.

The first empirical application of the input-output model in the Anglo-American world dates from 1936, when Wassily Leontief published an input-output system of the U.S. economy. Leontief simplified Walras' generalized model so that the model's equations could be estimated empirically. He used two simplifying assumptions. First, the large number of *commodities* in the Walrasian model were aggregated into relatively few outputs, one for each *industry*[2]*.* Second, the supply equation for labor and the demand equations for final consumption were abandoned, and the remaining production equations were expressed in the simplest linear form.

These simplifying assumptions define a sharp difference between input-output and most other conventional economic models. The assumption of linearity does not allow factor substitution or economies of scale. Time is missing, yet the purchase of inputs by one industry to make goods to sell to other industries implies a period analysis. In the "real world," the prevalence of joint products

[1] This entire appendix is quoted, with permission, from Micro IMPLAN User’s Guide: Version 91-F, pages G-1 through G-15.
[2] All terms which appear in italics in the text are defined in a short glossary at the end of this appendix.

and multiproduct plants makes it impossible to aggregate only those plants with similar output and input structures; yet, the model assumes a single homogeneous output generated from the same inputs for each producing industry.

Given these assumptions, the model is starkly simple. Its key variables are the outputs of industrial categories ("industries") into which the economy is divided. Each industry's output consists of summing its sales to all other industries and to *final demand,* i.e., to ultimate consumers rather than other producing industries. The amount of each product consumed in each industry depends only on the level of output for that industry. *Equilibrium* in the economy is attained when each industry's output equals its total purchases, which are in turn determined by the output of all other industries.

Because of these simplifying assumptions, the model is empirically tractable. The implausible assumptions for the production function do not appear to restrict the model too badly. Technology changes are slow enough so that the input coefficient matrix of one year seems to be good for several years. Even out-of-date tables are useful in that they can show the maximum input requirement for each industry. Perhaps most important of all, input-output models pass the critical test: for many purposes, they predict reasonably well.

The Basic Input-Output Model

The key to input-output analysis is the construction of the input-output or *transactions table,* which shows the flow of commodities from each of a number of producing industries to all consuming industries and final demand. From these flows between economic industries, two other structural tables can be developed: (1) A table of *technical coefficients or direct requirements* (terms used interchangeably here) and (2) a table of *direct and indirect coefficients or total requirements* (also interchangeable terms). Each of these three tables and their significance is discussed below.

The Transactions Table

Given that many industries produce more than one commodity, production information is often tabulated on an industry (I) by commodity (C) basis;

1) A *Make Matrix* (CxI) contains the value of commodities produced by the different industries. Note that one particular industry may produce a variety of commodities. Normally, it is assumed that the production of multiple commodities takes the form of one principal product and one or more byproducts.

2) A *Use Matrix* (IxC) contains the value of commodities and imports used by each industry in the production process. Note that one particular type of commodity may be used by a variety of different industries.

A traditional I-0 transactions table, however, is on an industry by industry (IxI) basis. It is therefore necessary to combine the Use and Make matrices in such a way that each industry is shown buying and selling from other industries. The "Industry-Technology Assumption" presumes that any by-products of an industrial process are technically related to the main production process, so that all commodities produced by an industry are produced with the same input structure. Therefore, since industries are classified/named based on their principal output, all individual producers within a particular industry are assumed to have the same input mix regardless of their output product mix. Thus, demand for an industry's output is in effect demand for a bundle of goods -- the principal output plus any joint production generated by the industry. This one-to-one correspondence between an industry and its "bundle of goods" output, enables the Use and Make matrices to be combined into an IxI transactions table.

Table A depicts a highly simplified, aggregated version of a transactions table in which all producing industries have been aggregated into three "super-industries:" agriculture, manufacturing, and services. A transactions table portrays the dollar flows of goods and services among industries in an economy for a given accounting period. In this table, sales and purchase transactions within the economy are set forth in a matrix of rows and columns. Each row shows the output sold by each industry shown along the left-hand side of the table to each industry shown across the top of the table. Each column shows the purchases made by each industry shown along the top of the table from the industries along the left-hand side. Because this is a square table, one row corresponds to each column. The entry in each cell represents a purchase for the column industry and a sale for the row industry.

Table B-1. Illustrative Transactions Table

	Purchasing Industries				
Producing Industries	**Agriculture**	**Manufacturing**	**Services**	**Final Demand**	**Total Output**
Agriculture	10	6	2	18	36
Manufacturing	4	4	3	26	37
Services	6	2	1	35	44
Primary Inputs	16	25	38	0	79
Total Outlay	36	37	44	79	196

Thus, the entries in the first column show agriculture purchasing $10 worth of output from itself, $4 worth of output from manufacturing, $6 from services, and $16 from primary inputs (e.g. labor), summing to a total outlay of $36. Reading along the row, agriculture sells $10 worth of output to itself, $6 to manufacturing, $2 to services, and $18 to final demand. Summing the sales results in a total output value of $36.

The distinction commonly made in economic analysis between the production of goods and services and their final disposition is reflected by dividing the industries of the transactions table into four groups or "quadrants", each representing either intermediate transactions, primary inputs, or final demand. Figure I presents a theoretical table with the four divisions.

Quadrant I shows the intermediate transactions, that is, the flow of goods and services which are both produced and consumed in the process of current production. This quadrant can have as many or as few industries as desired. Limitations in data and processing equipment often restrict the number of industries included in a model to 100 or fewer, but some national models have well over 400 industries.

Final demand, or the ultimate consumers' purchases from the producing industries, are recorded in the second quadrant. (To distinguish them from the industries in Quadrant 1, the components of final demand are called "Institutions".) The third quadrant represents the primary inputs of production. Here again, the decision as to the amount of detail to include is left to the model builder. Table A has only one industry in Quadrants II and III, whereas Figure 1 shows both final demand and primary inputs broken down into four industries each, i.e., the main industries of the national accounting system.

The fourth quadrant is sometimes omitted from published input-output tables, but it should be included if portrayal of a complete economy is desired. Quadrant IV records the primary inputs into final demand institutions, including such typical entries as income of government employees (H_G in Figure 1) and imports consumed directly by households (M_C in Figure 1). Note that in input-output terms, Quadrant I is endogenous to the model, while Quadrants II, III, and IV are exogenous.

Figure B-1. Structure of an Input-Output Transactions Table

		Purchasing Sectors							
		Intermediate Demand			**Final Demand**				**Total**
		Agriculture	*Manufacturing*	**Services**	**Household Consumption**	**Government Purchases**	**Capital Formation**	**Exports**	**Gross Output**
Producing Sectors		I. Intermediate Production and Consumption			II. Final Outputs of Producing Sectors				
Intermediate Inputs	Agriculture	X_{11}	X_{1j}	X_{1n}	C_1	G_1	I_1	E_1	X_1
	Manufacturing	X_{i1}	X_{ij}	X_{in}	C_i	G_i	I_i	E_i	X_i
	Services	X_{n1}	X_{nj}	X_{nn}	C_n	G_n	I_n	E_n	X_n
Primary Inputs	Payments to:	III. Primary Inputs to Production			IV. Primary Inputs to Final Demand				
	Households	H_1	H_j	H_n	H_C	H_G	H_I	H_E	H
	Government	T_1	T_j	T_n	T_C	T_G	T_I	T_E	T
	Depreciation	D_1	D_j	D_n	D_C	D_G	D_I	D_E	D
	Imports	M_1	M_j	M_n	M_C	M_G	M_I	M_E	M
Total Gross Outlays		X_1	X_j	X_n	C	G	I	E	X

In addition to summarizing basic consumption and production patterns, a transactions table can be used to describe other economic factors. For example, the following can be calculated from Figure 1:

Summing across a row, intermediate demand plus final demand measures the Total Gross Output of industry "i". Thus, in an "n"-industry model[3]:

$$X_i = \sum_{j=1}^{n} X_{ij} + (C_i+G_i+I_i+E_i)$$

Where: X_i = *Total Gross Output of Industry j*
$\sum X_{ij}$ = *Intermediate Demand for the output of Industry i*
$(C_i+G_i+I_i+E_i$ = *Final Demand for the output of Industry i*

Summing down a column, intermediate inputs plus primary inputs yields the Total Gross Outlays of industry j. Thus:

$$X_j = \sum_{ij=1}^{n} X_{ij} + (H_j+T_j+D_j+M_j)$$

Where: X_j = *Total Gross Outlays of Industry j*
$\sum X_{ij}$ = *Intermediate Inputs for Industry j*
$(H_j+T_j+D_j+M_j)$ = *Primary Inputs for Industry j*

We may also sum across the totals row or down the totals column to obtain the economy's Total Gross Output:

$$X = \sum_{i=1}^{n} X_i + (H+T+D+M)$$

$$X = \sum_{j=1}^{n} X_j + (C+G+I+E)$$

Now, since in equilibrium,

$$\sum_{i=1}^{n} X_i = \sum_{j=1}^{n} X_j$$

all intermediate flows cancel out. We then have:

(H + T + D) + M = C + G + I + E

or: Value Added + Imports = Final Demand.

Transferring imports to the right-hand side of the equation gives the traditional social accounting identity of Gross Regional Income (allocations approach) and Gross Regional Product (expenditures approach)[4] that is:

H + T + D = C + G + I + E - M

or: Gross Regional Income = Gross Regional Product[5]

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[3] The definitions of C, G, etc can be found by reading Figure 1.

[4] Where the "expenditures approach" tracks purchases by an industry**,** while the "allocations approach" tracks sales.

Thus, Gross Regional Product can be calculated both by the traditional income allocations approach and by the expenditures approach from an input-output model transactions table.

The Technical Coefficients, or Direct Requirements Table

Table B is a table of direct requirements or technical coefficients for the illustrative transactions table, Table A. The entries in this table are to be interpreted as the minimal requirements from each of the producing industries at the left of the table in order for each industry at the top to produce one dollar's worth of output for final demand. The word "minimal" is important. If it takes 2 tons of ore to yield 1 ton of iron, no doubt the same iron could be produced from even more ore, but as long as iron ore has value, no one would be foolish enough to use more than the absolutely required 2 tons.

Table B-2. Direct Requirements Table*

	Purchasing Industries		
Producing Industries	**Agriculture**	**Manufacturing**	**Services**
Agriculture	.278	.162	.045
Manufacturing	.111	.108	.068
Services	.167	.054	.023
Primary Inputs	.444	.676	.864

* *Each entry represents the inputs that the column industry requires from the row industry to produce a dollar's worth of output.*

These direct requirements or technical coefficients are determined by dividing the column entries for agriculture, manufacturing, and services in the illustrative transactions table (Table A) by the total outlay of the respective column. In this example, the manufacturing industry requires 16.2 cents worth of input from agriculture ($6/$37), 10.8 cents from manufacturing industries, and 5.4 cents from services in order to produce one dollar of output. In other words, the 16.2 cents would be interpreted as the "dollar's worth of inputs from agriculture per dollar's worth of output from manufacturing. " The remaining inputs to the manufacturing industry come from the exogenous or primary inputs part of the model.

Using standard notation (as in Figure 1), the technical coefficients, a_{ij}, shown in Table B are computed as follows:

$$a_{ij} = X_{ij}/X_j \qquad i, j = 1...... n$$

where X_{ij} is the sales by industry i to industry j, and X_j is the total purchases of industry j. By definition, $X_j = X_i$ for all endogenous industries, i.e., all producing industries within the technical coefficients matrix of Quadrant I. The computation of a_{ij} for all cells in the first quadrant of the transactions table results in a matrix of a_{ij}'s or a "direct coefficients" table. Each column of a_{ij} represents a production function for that industry. Economists define the production function as the physical relation between the value of resource inputs and the value of the output of goods and services.

[5] "Regional" refers to any functional economic unit, from national to local. The "region" is defined by the model builder.

The direct coefficients embody most of the simplifying assumptions of input-output analysis. Input-output economics assumes that fixed proportions exist in all production processes; thus, the direct coefficients are constants. Once the coefficients have been developed, they remain constant for as long as the model is used. Further, when output is to be increased n times, all inputs must also be increased n times. This property, called constant returns to scale, means that average cost in real terms is the same at all output levels. Once an optimal combination of input factors is chosen, any level of output is obtainable simply by adjusting all inputs proportionately to the new output level. In addition, constant coefficients imply no substitution among inputs. A third condition implied by constant coefficients is production by each industry of a single, unvarying output. An aggregated industry is assumed to continue to produce the same average or homogeneous product it did at the time the model was developed.

These conditions, in defiance of many other economic models and theory, may not be unreasonable when one examines reality. There are many ways of producing any good. Each method uses some set of fixed proportions among inputs. Among all the possible ways, one is best at any given moment; that is the method which firms use. In this case, one may think of input-output tables as reflecting the set of "best" processes existing at that moment. That is, once a production method is adopted, it will be retained for a certain period, and it may be used to attain all possible output levels. The process may well change over time; therefore, the technical coefficients in an input-output system should be reviewed from year to year.

Economists usually assume that when output increases, the input requirements may increase more or less in direct proportion to the increase in output. However, statistical evidence suggests that the average cost of goods is independent of the scale of output in a great many cases. Thus, although not totally defensible theoretically, the assumptions brought about by constant coefficients in the input-output system may not be too much out of line with available facts. The important point is that if one is willing to accept the input-output assumptions, one can present the inter-industrial technical relations of the entire economy very neatly in a single input-output table. Such a table can be made and used, whereas without such simplifying assumptions, model estimation is not possible.

The Direct and Indirect Coefficients or Total Requirements Table

One of the most important applications of the input-output model is to calculate the equilibrium output levels in each industry of the economy. Output is in equilibrium if it is just equal to the quantity demanded for all purposes, such as inputs for production, consumption, investment, and exports. Once the transactions table is balanced (X_i's equal X_j's; i=j) and aggregate final demand equals aggregate primary inputs, an equilibrium exists.

Now suppose that someone, probably in a final demand institution, would like to buy more. This starts a chain reaction of increasing production everywhere. Using the table of technical coefficients (Table B) and given a lot of time, it is possible to calculate by hand the reaction as it ripples through all industries in the economy.

For example, suppose a foreign country would like to purchase $1 more from the agriculture industry. Using Table B, one can trace through the results. In order to sell an additional dollar's worth of output to final demand (in this case, exports), the agriculture industry must purchase 27.8 cents of output from itself, 11.1 cents output of output from the manufacturing industry, and 16.7 cents of output from the services industry. This is the first round. Now for agriculture to sell 27.8 cents to itself, it must again purchase 7.7 cents more output ($.278 times $.278) from itself and 3.1 cents ($.278 times $. 111) from manufacturing and 4.6 cents ($.278 times $.167) from services. The second round is not finished, because for manufacturing to sell 11.1 cents to agriculture, it must buy 1.8 cents ($.111 times $.162) from agriculture, 1.2 cents ($.111 times $.108) from itself, and 0.6 cents ($.111 times $.054) from services. Services must also purchase 0.8 cents (16.7 cents times .045) from agriculture, 1.1 cents (16.7 cents times .068) from manufacturing, and 0.4 cents (16.7 cents times .023) from itself to sell 16.7 cents to agriculture. In just the first two rounds, agriculture has produced $1 for export, 27.8 cents plus 7.7 cents for itself, 1.8 cents for manufacturing, and 0.8 cents for services, totaling $1.38. Now, if one were to follow this process ad infinitum, the total amount each industry would be required to produce could be calculated.

Leontief devised a much simpler method of determining the total output requirements resulting from a final demand change using matrix algebra techniques. The Leontief method determines total industry requirements directly. (If one desires the round-by-round effects, the cumbersome method described above would have to be used).

The Leontief method can be demonstrated using the information on final demands and total outputs from Table A combined with the information contained in Table B. From this information, the following system of equations can be developed:

$X_1 = .278\ X_1 + .162\ X_2 + .045\ X_3 + Y_I$

$X_2 = .111\ X_1 + .108\ X_2 + .068\ X_3 + Y_2$

$X_3 = .167\ X_1 + .054\ X_2 + .023\ X_3 + Y_3$

where X_1, X_2, and X_3 are the total outputs of the three endogenous industries, while Y_I, Y_2, and Y_3 are the respective processing industries' sales to final demand, and the coefficients are the entries in the direct requirements table (Table B).

In matrix notation, the system becomes:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} .278 & .162 & .045 \\ .111 & .108 & .068 \\ .167 & .054 & .023 \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

or more simply stated:

$$\mathbf{X = AX + Y}$$

where **X** is the vector of total outputs, **A** is the matrix of direct coefficients, and **Y** is the vector of final demands.

The above may also be written:

$X_1 - .278\ X_1 - .162\ X_2 - .045\ X_3 = Y_1$

$X_2 - .111\ X_1 - .108\ X_2 - .068\ X_3 = Y_2$

$X_3 - .167\ X_1 - .054\ X_2 - .023\ X_3 = Y_3$

or:

$(1 - .278)\ X_1 - .162\ X_2 - .045\ X_3 = Y_1$

$- .111\ X_1 + (1 - .108)\ X_2 - .068\ X_3 = Y_2$

$- .167\ X_1 - .054\ X_2 + (1 - .023)\ X_3 = Y_3$

Again, in matrix notation:

$$\begin{bmatrix} (1-.278) & .162 & .045 \\ .111 & (1-.108)) & .068 \\ .167 & .054 & (1-.023)) \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

which may also be written:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} .278 & .162 & .045 \\ .111 & .108 & .068 \\ .167 & .054 & .023 \end{bmatrix} \cdot \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

and may be reduced to:

(I - A) X = Y

where **I** is the identity matrix, **(I - A)** is called the Leontief matrix, and **A**, **X**, **Y** are as defined previously.

The coefficients are now in the proper form to solve the Leontief system and find the vector of outputs required to sustain a given vector of final demands. The mechanical process is first to find the Leontief inverse or the inverse of the Leontief **(I-A)** matrix. Inversion techniques are available in many math books, so they will not be dwelt on here. The Leontief inverse **(I - A)**$^{-1}$ is defined as the *total requirements matrix* and is presented in Table C.

Table B-3. Direct Requirements Table*

	Purchasing Industries		
Producing Industries	**Agriculture**	**Manufacturing**	**Services**
Agriculture	1.4459	.2678	.0852
Manufacturing	.1996	1.1628	.0901
Services	.2582	.1100	1.0431
Primary Inputs	1.91	1.54	1.22

* Each entry represents the output required both directly and indirectly from the row industry per dollar of deliveries to final demand by the column industry

To develop a solution, we must pre-multiply both sides of the above equation by the Leontief inverse, as follows:

(I - A)$^{-1}$ (I - A) X = (I - A)$^{-1}$ Y

which reduces to:

X = (I - A)$^{-1}$ Y

Using the information in table form and the above matrix, we can develop the following system of equations:

$$X_1 = 1.4459\ Y_1 + 0.2678\ Y_2 + 0.0852\ Y_3$$
$$X_2 = 0.1996\ Y_1 + 1.1628\ Y_2 + 0.0901\ Y_3$$
$$X_3 = 0.2582\ Y_1 + 0.1100\ Y_2 + 1.0431\ Y_3$$

Returning to our example, when a foreign country (or final demand institution outside of the model "region") wants to purchase $1 more from the agriculture industry, we would like to determine the total increase in output resulting from this $1 increase in final demand.

Using the above system of equations and looking at the $1 increase only, agriculture sales to final demand (Y_1) would equal 1, and manufacturing (Y_2) and services (Y_3) sales to final demand would be zero. After multiplying through, agriculture total output (X_1) equals $1.4459 (1 times the coefficient associated with Y_1), manufacturing output (X_2) equals $.1996, and services output (X_3) equals $.2582. Summing the three outputs, we find the total increase in output resulting from a $1 increase in final demand of the agriculture industry to be $1.91. We have found the total output, both direct and indirect, that this hypothetical economy is required to produce in order for the agriculture industry to sell one more dollar of output to a final demand industry. The total output requirement divided by the output sold to the final demand industry is designated as the "output multiplier. " The output multiplier is calculated by summing the appropriate column of the Leontief inverse. As presented in the total requirements table (Table C), by summing each column the output multipliers are 1.91, 1.54, and 1.22 for the agriculture, manufacturing, and service industries, respectively.

Multipliers

We have seen how input-output analysis is developed to tell us the effect on total output resulting from a given change in the amount of output purchased by a final demand institution. The answer is straightforward and involves only an interpretation of the Leontief inverse. The output directly sold to final demand is exogenous to the model, i.e., it must be determined outside the model. Once this "direct" change is determined, the direct and indirect outputs by industry can be calculated by premultiplying by the Leontief inverse.

The output multiplier developed in the previous subsection relates an increment of direct or final output to the resulting increment of total output -- direct and indirect combined. Although the output multiplier represents total requirements per unit of final output, it is not a particularly useful concept except as an indicator of the degree of structural interdependence between each industry and the rest of the economy. There are, however, many other multipliers that can be developed with input-output analysis, depending on the purpose of the economic study. Income and employment are the multipliers of interest in most studies, although, in recent years, water and pollution multipliers have also been frequently used. A multiplier can be developed for most any input or factor that has a determinable relationship with a industry's output. For more information, see Appendix E of the Micro IMPLAN User's Guide - "Multipliers".

IMPLAN's Glossary of Terms

Byproducts: During the production process, an industry may produce more than one output. The industry is classified according to the primary product, while secondary products are termed "*byproducts*".

Commodities: The goods and services produced by industries are classified in terms of one or more product types, or "*commodities*".

Direct and Indirect Coefficients (see also Total Requirements): The amount of output from industry i required (both directly and indirectly) to deliver one dollar's worth of industry j's output to final demand.

Direct Requirements (see also Technical Coefficients): The dollar value of industry i's output required by industry j to produce one dollar's worth of output.

Equilibrium: In the I-0 sense, equilibrium occurs when Total Gross Output equals Total Gross Outlays.

Final Demand: The ultimate consumers of commodities (goods and services).

Industry: The manufacturer or provider of goods and/or services. Industries are categorized on the basis of their primary product, though they may produce a range of commodities.

Make Matrix: The values of commodities (columns) produced by the different industries (rows). The sum of each row is that industry's Total Industry Output. The sum of each column is that commodity's Gross Commodity Production.

Technical Coefficients (see also Direct Requirements): The dollar value of industry i's production required by industry j to produce one dollar's worth of output.

Total Requirements Matrix (see also Direct and Indirect Coefficients): The amount of output from industry i required (both directly and indirectly) to deliver one dollar's worth of industry j's output to final demand.

Transactions Table: The flow of commodities from each of a number of producing industries to all consuming industries and final demand. This flow is expressed in terms of the dollar value of the commodities traded.

Use Matrix: The values of commodities and imports (rows) used in production by each industry (columns). The sum of each column is that industry's Gross Industry Commodity Demand. The sum of each row is the Intermediate Demand for that commodity.

APPENDIX C

TAX IMPACT

IMPACT NAME: Annual OSB Impacts MULTIPLIER: Type SAM

		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Taxes	Total
	Transfers	-57,213					*-57,213*
Enterprises *(Corporations)*	Total	*-57,213*	*0*	*0*	*0*	*0*	*-57,213*
	Corporate Profits Tax				1,545,000		*1,545,000*
	Indirect Bus Tax: Custom Duty					42,771	*42,771*
	Indirect Bus Tax: Excise Taxes					131,068	*131,068*
	Indirect Bus Tax: Fed NonTaxes					45,708	*45,708*
	Personal Tax: Estate and Gift Tax						*0*
	Personal Tax: Income Tax			1,943,585			*1,943,585*
	Personal Tax: NonTaxes (Fines- Fees						*0*
	Social Ins Tax- Employee Contribution	1,434,707	97,900				*1,532,608*
	Social Ins Tax- Employer Contribution	1,489,932					*1,489,932*
Federal *Government* NonDefense	Total	*2,924,640*	*97,900*	*1,943,585*	*1,545,000*	*219,548*	*6,730,672*
	Corporate Profits Tax				244,417		*244,417*
	Dividends				410,094		*410,094*
	Indirect Bus Tax: Motor Vehicle Lic					9,374	*9,374*
	Indirect Bus Tax: Other Taxes					82,758	*82,758*
	Indirect Bus Tax: Property Tax					771,348	*771,348*
	Indirect Bus Tax: S/L NonTaxes					67,119	*67,119*
	Indirect Bus Tax: Sales Tax					1,362,924	*1,362,924*
	Indirect Bus Tax: Severance Tax					2,395	*2,395*
	Personal Tax: Estate and Gift Tax						*0*
	Personal Tax: Income Tax			362,009			*362,009*
	Personal Tax: Motor Vehicle License			18,285			*18,285*
	Personal Tax: NonTaxes (Fines- Fees			219,165			*219,165*
	Personal Tax: Other Tax (Fish/Hunt)			8,685			*8,685*
	Personal Tax: Property Taxes			15,393			*15,393*
	Social Ins Tax- Employee Contribution	41,782					*41,782*
	Social Ins Tax- Employer Contribution	138,775					*138,775*
State/Local *Govt* NonEducation	Total	*180,556*	*0*	*623,536*	*654,511*	*2,295,919*	*3,754,521*
Total		*3,047,983*	*97,900*	*2,567,121*	*2,199,510*	*2,515,466*	*10,427,981*

APPENDIX D

TAX IMPACT

IMPACT NAME: Facility Construction MULTIPLIER: Type SAM

		Employee Compensation	Proprietary Income	Household Expenditures	Enterprises (Corporations)	Indirect Business Taxes	Total
	Transfers	-27,919					*-27,919*
Enterprises *(Corporations)*	Total	*-27,919*	*0*	*0*	*0*	*0*	*-27,919*
	Corporate Profits Tax				601,272		*601,272*
	Indirect Bus Tax: Custom Duty					25,750	*25,750*
	Indirect Bus Tax: Excise Taxes					78,908	*78,908*
	Indirect Bus Tax: Fed NonTaxes					27,518	*27,518*
	Personal Tax: Estate and Gift Tax						*0*
	Personal Tax: Income Tax			1,208,704			*1,208,704*
	Personal Tax: NonTaxes (Fines- Fees						*0*
	Social Ins Tax- Employee Contribution	700,109	192,394				*892,503*
	Social Ins Tax- Employer Contribution	727,058					*727,058*
Federal *Government* NonDefense	Total	*1,427,167*	*192,394*	*1,208,704*	*601,272*	*132,176*	*3,561,714*
	Corporate Profits Tax				95,120		*95,120*
	Dividends				159,597		*159,597*
	Indirect Bus Tax: Motor Vehicle Lic					5,644	*5,644*
	Indirect Bus Tax: Other Taxes					49,823	*49,823*
	Indirect Bus Tax: Property Tax					464,382	*464,382*
	Indirect Bus Tax: S/L NonTaxes					40,408	*40,408*
	Indirect Bus Tax: Sales Tax					820,534	*820,534*
	Indirect Bus Tax: Severance Tax					1,442	*1,442*
	Personal Tax: Estate and Gift Tax						*0*
	Personal Tax: Income Tax			225,119			*225,119*
	Personal Tax: Motor Vehicle License			11,374			*11,374*
	Personal Tax: NonTaxes (Fines- Fees			136,283			*136,283*
	Personal Tax: Other Tax (Fish/Hunt)			5,404			*5,404*
	Personal Tax: Property Taxes			9,556			*9,556*
	Social Ins Tax- Employee Contribution	20,389					*20,389*
	Social Ins Tax- Employer Contribution	67,719					*67,719*
State/Local *Govt* NonEducation	Total	*88,108*	*0*	*387,735*	*254,718*	*1,382,234*	*2,112,795*
Total		*1,487,356*	*192,394*	*1,596,439*	*855,990*	*1,514,410*	*5,646,590*